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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/645,645	08/22/2003	Chandra Mouli	M4065.0674/P674	8786

45374 7590 11/26/2008

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EXAMINER	
MATTHEWS, COLLEEN ANN	

ART UNIT	PAPER NUMBER
2811	

MAIL DATE	DELIVERY MODE
11/26/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/645,645	MOULI, CHANDRA	
	Examiner	**Art Unit**	
	Colleen A. Matthews	2811	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *08/14/2008*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-3,5-13,15-37,55 and 56* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-3,5-13,15-37,55 and 56* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application

6) ☐ Other: _____.

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 08/14/2008 has been entered.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 1, 4, 11, 15-18 and 56 are rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Pat. No. 6,489,643 to Lee in view of U.S. Pub. No. 2002/0171077 to Chu et al. (Chu) and U.S. Pat. No. 6,117,702 to Nakamura et al. (Nakamura).

Regarding claim 1, Lee discloses a pixel cell for an image sensor (Fig 7 and Figure 8E), the pixel comprising:

a photodiode (Fig 7 - PPD) for generating charge in response to light and for amplifying the generated charge, the photodiode being formed within a substrate

(802/801) and below and upper surface thereof and comprising at least two of a first layer (806/810 or 808/812), having a first band gap (band gap inherent to n-type or p-type material) and at least two of a second layer (808/812 or 806/810) having a second band gap (band gap inherent to p-type or n-type material), where the first layers are alternated with the second layers;

a gate (804) of a transistor (Fig 7 - transfer transistor) adjacent to the photodiode for transferring the amplified charge from the photodiode.

Lee fails to disclose a graded buffer layer beneath a bottom layer of the photodiode. Chu discloses a photodiode (Fig 2, element 22 with electrodes 11 shown in Figure 4A) and a graded buffer layer beneath a bottom layer of the photodiode (2 and 38 are graded buffer layers, paragraph [0034] and paragraph [0039]). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Lee to have the graded buffer layer beneath a bottom layer of the photodiode as in Chu in order to improve device characteristics, such as enhancing absorption and speed of the image sensor (Chu, paragraph [0015]).

Lee fails to explicitly disclose wherein at least two first layers and the at least two second layers are configured to promote ionization of a first carrier type and suppressing ionizing of a second carrier type in the presence of an electric field. Nakamura teaches a photodiode with at least two first layers (Fig 13, 304) and at least two second layers (305) wherein at least two first layers and the at least two second layers are configured to promote ionization of a first carrier type (promotes electron ionization) and suppressing ionizing of a second carrier type in the presence of an

electric field (see col 3 lines 35-45). It would have been obvious to one of ordinary skill in the art at the time the invention was made to further modify Lee to configure the layers to promote ionization of a first carrier type and suppress ionizations of a second carrier type in order to reduce the electric field strength necessary for ionization of the carriers to enable low voltage drive.

Regarding claim 11, Lee discloses the pixel cell of claim 1 where at least a portion of the photodiode (PPD) is at a level below a level of a top surface of the substrate (801/802).

Regarding claim 15, Lee discloses the pixel cell of claim 1, where there is a reset transistor (Fig 7 – reset transistor) for resetting the photodiode to a predetermined voltage.

Regarding claim 16, Lee discloses the pixel cell of claim 1, further comprising a floating diffusion region (Fig 7 – floating node), where the transistor (Fig 7 – transfer transistor) is a transfer transistor for transferring charge from the photodiode to the floating diffusion region.

Regarding claim 17, Lee discloses the pixel cell of claim 1 where the photodiode is part of a CMOS image sensor (col 1 lines 6-10).

Regarding claim 18, Lee discloses the pixel cell of claim 1 where the photodiode is part of a charge coupled device image sensor (col 1 lines 12-16).

Regarding claim 56, Lee discloses a pixel cell for an image sensor (Fig 7 and Figure 8E), the pixel comprising:

a photodiode (Fig 7 - PPD) for generating charge in response to light and for amplifying the generated charge, the photodiode comprising at least two of a first layer (806/810 or 808/812), having a first band gap (band gap inherent to n-type or p-type material) and at least two of a second layer (808/812 or 806/810) having a second band gap (band gap inherent to p-type or n-type material), where the first layers are alternated with the second layers;

a gate (804) of a transistor (Fig 7 - transfer transistor) adjacent to the photodiode for transferring the amplified charge from the photodiode.

Lee fails to disclose a graded buffer layer beneath a bottom layer of the photodiode. Chu discloses a photodiode (Fig 2, element 22 with electrodes 11 shown in Figure 4A) and a graded buffer layer beneath a bottom layer of the photodiode (2 and 38 are graded buffer layers, paragraph [0034] and paragraph [0039]). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Lee to have the graded buffer layer beneath a bottom layer of the photodiode as in Chu in order to improve device characteristics, such as enhancing absorption and speed of the image sensor (Chu, paragraph [0015]).

Lee fails to explicitly disclose wherein at least two first layers and the at least two second layers are configured to promote ionization of a first carrier type and suppressing ionizing of a second carrier type in the presence of an electric field. Nakamura teaches a photodiode with at least two first layers (Fig 13, 304) and at least two second layers (305) wherein at least two first layers and the at least two second layers are configured to promote ionization of a first carrier type (promotes electron

ionization) and suppressing ionizing of a second carrier type in the presence of an electric field (see col 3 lines 35-45). It would have been obvious to one of ordinary skill in the art at the time the invention was made to further modify Lee to configure the layers to promote ionization of a first carrier type and suppress ionizations of a second carrier type in order to reduce the electric field strength necessary for ionization of the carriers to enable low voltage drive.

Claim 19 is rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Pat. No. 6,489,643 to Lee in view of U.S. Pub. No. 2002/0171077 to Chu et al. (Chu), U.S. Pat. No. 6,117,702 to Nakamura et al. (Nakamura) and in further view of U.S. Pat. No. 6,232,626 to Rhodes.

Regarding claim 19, Lee discloses the pixel cell of claim 1. Lee fails to disclose the substrate as silicon-on-insulator. Rhodes discloses a pixel cell where the substrate is a silicon-on-insulator substrate (col 6 lines 46-50). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Lee to have a silicon-on-insulator substrate like Rhodes to improve device isolation between devices on the substrate.

Claims 2-3, 5-8, 12-13, 20-29 and 32-34 are rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Pat. No. 6,489,643 to Lee in view of U.S. Pub. No. 2002/0171077 to Chu et al. (Chu), and U.S. Pat. No. 6,117,702 to Nakamura et al. (Nakamura) and U.S. Pat. No. 5,818,322 to Tasumi.

Regarding claims 20, Lee discloses a pixel cell for an image sensor (Fig 7 and Figure 8E), the pixel comprising:

a photodiode (Fig 7 - PPD) for generating charge in response to light and for amplifying the generated charge, the photodiode being formed within a substrate (802/801) and below and upper surface thereof and comprising at least two of a first layer (806/810 or 808/812) comprising a first material (n-type or p-type material) and at least two of a second layer (808/812 or 806/810) comprising a second material (p-type or n-type material) where the first layers are alternated with the second layers;

a gate (804) of a transistor (Fig 7 - transfer transistor) adjacent to the photodiode for transferring the amplified charge from the photodiode; and

Lee fails to explicitly disclose wherein at least two first layers and the at least two second layers are configured to promote ionization of a first carrier type and suppressing ionizing of a second carrier type in the presence of an electric field. Nakamura teaches a photodiode with at least two first layers (Fig 13, 304) and at least two second layers (305) wherein at least two first layers and the at least two second layers are configured to promote ionization of a first carrier type (promotes electron ionization) and suppressing ionizing of a second carrier type in the presence of an electric field (see col 3 lines 35-45). It would have been obvious to one of ordinary skill in the art at the time the invention was made to further modify Lee to configure the layers to promote ionization of a first carrier type and suppress ionizations of a second carrier type in order to reduce the electric field strength necessary for ionization of the carriers to enable low voltage drive.

Lee fails to disclose the layers configured such that there is a difference between the conduction band energies of the first and second materials and a difference between the valence band energies of the first and second materials. Tasumi discloses layers of first material (silicon) and second material (SiGe) and therefore discloses the feature of a difference between the valence band energies (of the Silicon and SiGe) layers and the conduction band energies (this is in inherent to the materials of Tasumi). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Lee to have a difference between the conduction band energies of the first layer and the second materials and the valence band energies of the first and second materials as in Tasumi in order to improve device characteristics, such as enhancing absorption and speed of the image sensor and reducing dark current.

Lee fails to disclose a graded buffer layer beneath a bottom layer of the photodiode. Chu discloses a photodiode (Fig 2, element 22 with electrodes 11 shown in Figure 4A) and a graded buffer layer beneath a bottom layer of the photodiode (2 and 38 are graded buffer layers, paragraph [0034] and paragraph [0039]). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Lee to have the graded buffer layer beneath a bottom layer of the photodiode as in Chu in order to improve device characteristics, such as enhancing absorption and speed of the image sensor (Chu, paragraph [0015]).

Regarding claims 2-3 and 5-6, Lee as modified discloses the pixel cell of claim 1 as above. Lee fails to disclose the differences of the conduction band energies of at least two first layers and the at least two second layers as greater than a difference

between the valance band energies of the first and second layer (claims 2-3). Lee also fails to disclose the layers formed of a material selected from the group consisting of Si, Si_xGe_{1-x}, $Si_xGe_{1-x}C_y$, GaAs, GaAlAs, InP, InGaAs, or InGaAsP (claim 5) and where the first layer is Si and the second layer is SiGe (claim 6).

Tasumi teaches a photodiode structure (Figures 1A-1C element 2) with Si and SiGe (col 3 line 63) formed in the groove (4) of the photodiode. It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Lee to include the alternating layers of Si and SiGe as in Tasumi in order to improve device characteristics, such as enhancing absorption and speed of the image sensor and reducing dark current. Additionally, the feature of a difference between the conduction band energies of the Si and SiGe layers as greater than a difference between the valence band energies in inherent in Lee as modified by Tasumi since the same materials (Si and SiGe) are used for the photodiode in Tasumi.

Regarding claims 21-22, Lee as modified discloses the pixel cell of claim 20 as above. Lee also fails to disclose the layers formed of a material selected from the group consisting of Si, Si_xGe_{1-x}, $Si_xGe_{1-x}C_y$, GaAs, GaAlAs, InP, InGaAs, or InGaAsP (claim 21) and where the first layer is Si and the second layer is SiGe (claim 22).

Tasumi teaches a photodiode structure (Figures 1A-1C element 2) with Si and SiGe (col 3 line 63) formed in the groove (4) of the photodiode. It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Lee to include the alternating layers of Si and SiGe as in Tasumi in order to improve

device characteristics, such as enhancing absorption and speed of the image sensor and reducing dark current.

Regarding claims 7-8 and 23-24, Lee as modified discloses the pixel cell of claims 6 and 22 as above. The modification of Tasumi further discloses where the layers of Si are doped to a first conductivity type and the layers of SiGe as taught by Tasumi are doped to a second conductivity type (col 5 lines 66-67 and col 6 lines 1-32).

Regarding claims 9-10 and 25-26, Lee as modified discloses the pixel cell of claims 1 and 20 as above. Lee fails to disclose where the first layer is Si_xGe_{1-x} or $Si_xGe_{1-x}C_y$ and the second layer is Si_yGe_{1-y} or $Si_xGe_yC_z$. Tasumi discloses the pixel cell of claim 1 where the first layer is Si_xGe_{1-x} or $Si_xGe_{1-x}C_y$ and the second layer is Si_yGe_{1-y} or $Si_xGe_yC_z$ (col 3 line 63). It would have been obvious to one of ordinary skill in the art at the time the invention was made to have the first layer is Si_xGe_{1-x} or $Si_xGe_{1-x}C_y$ and the second layer is Si_yGe_{1-y} or $Si_xGe_yC_z$ as in Tasumi in order to improve device characteristics, such as enhancing absorption and speed of the image sensor and reducing dark current.

Regarding claims 12 and 27, Lee as modified discloses the pixel cell of claims 1 and 20 as above. Lee fails to disclose the photodiode comprises approximately 10 to approximately 100 layers. Tasumi discloses the photodiode comprises approximately 10 to approximately 100 layers (Tasumi has 22 layers (Figure 1A), which falls within the claimed range). It would have been obvious to one of ordinary skill in the art at the time the invention was made to have the photodiode comprises approximately 10 to

approximately 100 layers as in Tasumi in order to improve device characteristics, such as enhancing absorption and speed of the image sensor and reducing dark current.

Regarding claim 13, Lee as modified discloses the pixel cell of claims 1 and 20 as above. Lee fails to disclose forming the layers of thickness of approximately 50 – 300 angstroms. Tasumi discloses forming layers of thickness of approximately 50-300 angstroms (50 angstroms, col 6 line 24). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the thickness of the layers between 50 – 300 angstroms as in Tasumi in order to improve device characteristics, such as enhancing absorption and speed of the image sensor and reducing dark current.

Regarding claim 28, Lee discloses the pixel cell of claim 20, where there is a reset transistor (Fig 7 – reset transistor) for resetting the photodiode to a predetermined voltage.

Regarding claim 29, Lee discloses the pixel cell of claim 20, further comprising a floating diffusion region (Fig 7 – floating node), where the transistor (Fig 7 – transfer transistor) is a transfer transistor for transferring charge from the photodiode to the floating diffusion region.

Regarding claims 32-34, Lee discloses an image sensor comprising:

an array of pixel cells (Fig 7 and Fig 8E) where at least one of the pixel cells comprises:

a photodiode (Fig 7 - PPD) formed below and upper surface of a substrate (801/802) the photodiode comprising at least two layers (806/810 or 805/808) and alternating with at least two layers (805/808 or 806/810)

and a gate (804) adjacent to the photodiode for transferring (Fig 7 - transfer transistor) the amplified charge form the photodiode.

Lee fails to disclose the two layers as Silicon and alternating with at least two layers of Si_xGe_{1-x}, where x is approximately 0.5 and wherein the layers of Si are doped to a first conductivity type and wherein the layers of Si_xGe_{1-x}, are doped to a second conductivity type. Tasumi teaches a photodiode structure (Figures 1A-1C element 2) with alternating layers of Si and Si_xGe_{1-x}, (col 3 line 63) where x is 0.6 (col 1 line 32) which is approximately 0.5 formed in the groove (4) of the photodiode. Tasumi also teaches the layers of Si are doped to a first conductivity type and the layers of SiGe as taught by Tasumi are doped to a second conductivity type (col 5 lines 66-67 and col 6 lines 1-32). It would have been obvious to one of ordinary skill in the art at the time the invention was made to to include the alternating layers of Si and Si_xGe_{1-x} as in Tasumi in order to improve device characteristics, such as enhancing absorption and speed of the image sensor and reducing dark current.

Lee fails to disclose a graded buffer layer formed within the substrate and below the photodiode. Chu discloses a photodiode (Fig 2, element 22 with electrodes 11 shown in Figure 4A) and a graded buffer layer within the substrate and below the photodiode (2 and 38 are graded buffer layers, paragraph [0034] and paragraph [0039]). It would have been obvious to one of ordinary skill in the art at the time the invention

was made to modify Lee to have the graded buffer layer beneath a bottom layer of the photodiode as in Chu in order to improve device characteristics, such as enhancing absorption and speed of the image sensor (Chu, paragraph [0015]).

Claims 30-31 and 35-37 are rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Pat. No. 6,489,643 to Lee in view of U.S. Pat. No. 6,117,702 to Nakamura et al. (Nakamura), U.S. Pub. No. 2002/0171077 to Chu et al. (Chu) and U.S. Pat. No. 5,818,322 to Tasumi and U.S. Pat. No. 6,232,626 to Rhodes.

Regarding claim 30, Lee as modified discloses the image sensor of claim 20. Lee fails to disclose readout circuitry electrically connected to the floating diffusion region. Rhodes discloses readout circuitry connected to a floating diffusion region for reading out charge (col 2 lines 5-15). It would have been obvious to one of ordinary skill in the art at the time the invention was made to Lee to have readout circuitry as in Rhodes in order to allow access to image data.

Regarding claim 31, Lee as modified discloses the image sensor of claim 20. Lee fails to disclose circuitry peripheral to the array, the peripheral circuitry being at a surface of the substrate, where the substrate is silicon-on-insulator. Rhodes discloses circuitry peripheral to the array (Figure 1), the peripheral circuitry being at a surface of the substrate where the substrate is silicon-on-insulator (col 6 lines 46-50). It would have been obvious to one of ordinary skill in the art at the time the invention was made to Lee to have circuitry as in Rhodes in order to allow access to image data.

Regarding claim 35, Lee discloses an image sensor comprising:

an array of pixel cells (Fig 7 and Fig 8E) where at least one of the pixel cells comprises:

a photodiode (Fig 7 - PPD) formed below and upper surface of a substrate (801/802) the photodiode comprising at least two layers (806/810 or 805/808) of a first material (n-type or p-type) alternating with at least two layers (805/808 or 806/810) of a second material (p-type or n-type), and wherein the layers are configured to promote ionization of a first carrier type and suppressing ionizing of a second carrier type (col 5 lines 20-30).

and a gate (804) of a transistor (Fig 7 - transfer transistor) adjacent to the photodiode;

a floating diffusion region (Fig 7 – floating node) electrically connected to the transistor (transfer transistor)

Lee fails to disclose the two layers as selected from the group consisting of Si, Si_xGe_{1-x}, $Si_xGe_{1-x}C_y$, GaAs, GaAlAs, InP, InGaAs, and InGaAsP. Tasumi teaches a photodiode structure (Figures 1A-1C element 2) with alternating layers of Si and Si_xGe_{1-x}, (col 3 line 63). It would have been obvious to one of ordinary skill in the art at the time the invention was made to include the alternating layers of Si and Si_xGe_{1-x} as in Tasumi in order to improve device characteristics, such as enhancing absorption and speed of the image sensor and reducing dark current.

Lee fails to disclose a graded buffer layer formed withing the substrate and below the photodiode. Chu discloses a photodiode (Fig 2, element 22 with electrodes 11

shown in Figure 4A) and a graded buffer layer within the substrate and below the photodiode (2 and 38 are graded buffer layers, paragraph [0034] and paragraph [0039]). It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Lee to have the graded buffer layer beneath a bottom layer of the photodiode as in Chu in order to improve device characteristics, such as enhancing absorption and speed of the image sensor (Chu, paragraph [0015]).

Lee fails to explicitly disclose the image sensor with a processor system including a processor coupled to the image sensor and readout circuitry electrically connected to the floating diffusion region. Rhodes discloses a processor system (Fig 14) including a processor (444-CPU) coupled to the image sensor (442-CMOS IMAGER) and with readout circuitry electrically connected to the floating diffusion region (col 2 lines 5-15). It would have been obvious to one of ordinary skill in the art at the time the invention was made to Lee to have processor system as in Rhodes in order to allow access to image data.

Regarding claims 36-37, Lee as modified discloses the system of claim 35. The modification of Tasumi discloses the layers configured such that a difference between the conduction band energies of the first material (silicon) and the second materials (SiGe) is greater than a difference between the valence band energies of the first and second materials (this is in inherent to the materials of Tasumi).

Claim 55 is rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Pat. No. 6,489,643 to Lee in view of U.S. Pat. No. 6,117,702 to Nakamura et al. (Nakamura).

Regarding claim 55, Lee discloses a pixel cell for an image sensor (Fig 7 and Figure 8E), the pixel comprising:

a photodiode (Fig 7 - PPD) for generating charge in response to light and for amplifying the generated charge, the photodiode being formed within a substrate (802/801) and below and upper surface thereof and comprising at least two of a first layer (806/810 or 808/812), having a first band gap (band gap inherent to n-type or p-type material) and at least two of a second layer (808/812 or 806/810) having a second band gap (band gap inherent to p-type or n-type material), where the first layers are alternated with the second layers;

a gate (804) of a transistor (Fig 7 - transfer transistor) adjacent to the photodiode for transferring the amplified charge from the photodiode.

Lee fails to explicitly disclose wherein at least two first layers and the at least two second layers are configured to promote ionization of a first carrier type and suppressing ionizing of a second carrier type in the presence of an electric field. Nakamura teaches a photodiode with at least two first layers (Fig 13, 304) and at least two second layers (305) wherein at least two first layers and the at least two second layers are configured to promote ionization of a first carrier type (promotes electron ionization) and suppressing ionizing of a second carrier type in the presence of an electric field (see col 3 lines 35-45). It would have been obvious to one of ordinary skill

in the art at the time the invention was made to further modify Lee to configure the layers to promote ionization of a first carrier type and suppress ionizations of a second carrier type in order to reduce the electric field strength necessary for ionization of the carriers to enable low voltage drive.

Response to Arguments

Applicant's arguments filed 08/14/2008 have been fully considered but they are not persuasive. Applicant’s arguments with respect to claim 32 (page 12-13) that Tasumi and Lee are not combinable. Examiner disagrees. One of ordinary skill in the art would look to prior similar structures in determining materials for new photodiodes, such as other photodiodes. Tasumi discloses the motivation of using the specified materials and claimed limitations to reduce dark current (col 2 lines 63-64).

Applicant's arguments with respect to claims 1, 20, 32, 55 and 56 regarding promoting and suppressing carrier ionization in the presence of an electric field have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Colleen A. Matthews whose telephone number is (571)272-1667. The examiner can normally be reached on Monday - Friday 8AM-4:30PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Lynne Gurley can be reached on 571-272-1670. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/C. A. M./
Examiner, Art Unit 2811

/Lynne A. Gurley/
Supervisory Patent Examiner, Art Unit 2811